ARSENIC

By William E. Brooks

Domestic tables were prepared by Elsie Isaac, statistical assistant, and the world production table was prepared by Regina R. Coleman, international data coordinator.

In 2003, the United States produced no arsenic and domestic demand was met entirely by imported arsenic trioxide (As_2O_3) and arsenic metal. China, as in past years, was the major supplier of As_2O_3 and arsenic metal for the United States. Mexico also supplied significant quantities of As_2O_3, and Japan continued to be an important source of arsenic metal. There has been no domestic production of As_2O_3 since 1985 when the copper smelter in Tacoma, WA, closed. The United States was the world's largest user of arsenic, principally as a preservative in pressure-treated wood.

Legislation and Government Programs

In February 2002, the U.S. Environmental Protection Agency (EPA) announced that it had received a voluntary request from the producers of chromated copper arsenate (CCA) to stop the use of CCA in treatment of certain lumber products. This action was intended to effectively eliminate the use of CCA-treated lumber for residential applications (U.S. Environmental Protection Agency, 2002).

CCA has been the main preservative used for pressure-treated wood products that are used out-of-doors, the use of which increased during the building and housing boom of the 1980s. The composition of CCA wood preservative depends upon geography and such wood-destroying factors as termites; the most widely used CCA wood preservative is type C, which contains hexavalent chromium [as chromium oxide (CrO_3) (47.5%)], copper [as cupric oxide (CuO) (18.5%)], and arsenic [as As_2O_3 (34.0%)] (Roskill Information Services Ltd., 1992, p. 66). An average residential deck may contain more than 0.7 kilogram arsenic, and arsenic release through degradation or disposal of this wood in a landfill or incinerator is of environmental concern (Home Depot, Inc., 2004; Bleiwas, 2003§[1]). In 2003, in response to consumer health concerns, U.S. manufacturers of arsenical wood preservatives began a voluntary transition from CCA to alternative wood preservatives after consultations with the EPA (American Wood Preservers Institute, 2003§; U.S. Environmental Protection Agency, 2003§). Alternatives to CCA wood preservative include alkaline copper quaternary, copper azole, and copper citrate; ammoniacal copper zinc arsenate and ammoniacal copper quaternary; silver-based biocides; and an unspecified copper-based preservative with a cobiocide (National Mining Association Mining Week, 2003; Commonwealth of Pennsylvania Department of Environmental Protection, 1999§; Health Canada, 2003§; YellaWood, Inc., 2004§).

On December 31, the voluntary phasing out of CCA-treated wood for certain residential uses, such as play structures, picnic tables, decks, fencing, and boardwalks, was completed. Wood treated prior to that date could still be used, and structures already in place would not be affected. Industrial-use wood products, such as marine timber and pilings, utility poles, shakes and shingles, plywood roof decking, plywood flooring, and glue-laminated beams, however, may still be treated with CCA. The EPA indicated that there is no reason to remove CCA-treated structures nor does the EPA recommend removing soils near these structures. In order to better inform buyers, however, the EPA will require that CCA-treated lumber, which commonly has a pale greenish color, be labeled "Treated with Chromated Copper Arsenate" to indicate that the product contains arsenic (Pittman, 2001; U.S. Environmental Protection Agency, 2002). This label also contains such consumer information as site use precautions and safe handling information (Home Depot, Inc., 2004).

Environmental Issues

Arsenic and human health are of domestic and international concern. The University of California-Berkeley, for example, coordinates an Arsenic Health Effects Research Program (Smith, 2003§); natural arsenic in aquifers, geothermal systems, and the food chain is the subject of a workshop scheduled for August 2004 in Florence, Italy, sponsored by the International Geological Congress (2003§). The World Health Organization is concerned with the high levels of arsenic present in ground water in 17 countries around the world that include Bangladesh, China, India, and Vietnam (Pearce, 2003). Arsenic in pressure-treated wood has been banned or restricted in Australia, Denmark, Germany, Indonesia, Japan, Sweden, Switzerland, and Vietnam (Clean Water Action, 2001§). In December 2002, approximately 20 metric tons (t) of arsenic was spilled in China's Guangxi Province causing pollution of nearby rivers (Planet Ark, 2003§). Arsenic has been associated with lung and kidney cancer mortality in Cordoba, Argentina (Hopenhayn-Rich, Biggs, and Smith, 1998). Tobacco farmers around the world use arsenic pesticides to kill ants and other insects; however, the arsenic absorbed by the plant may find its way into cigarettes and smokers' lungs (Health Canada, 2004§). The therapeutic use of small amounts of arsenic as an antitumor agent has been investigated (Science News, 2004).

The U.S. Geological Survey (USGS) cosponsored a Natural Science and Public Health Conference in April 2003, in Reston, VA; topics discussed included arsenic in ground water in Michigan, estimates of U.S. ground water arsenic concentrations, drinking water

[1]References that include a section mark (§) are found in the Internet References Cited section.

arsenic levels, and arsenic in metal-rich coals in China. Other USGS arsenic-related research programs include the Arsenic Studies Group; arsenic associated with massive sulfide deposits in the eastern United States; arsenic in ground water; the impact of regional geology on arsenic content of ground water in New England; arsenic contamination associated with abandoned mines in California; elevated arsenic content of water wells in Iowa; transport of arsenic from poultry feed amendments into the Chesapeake Bay Watershed; contamination of wells caused by pesticides; bedrock mineralogical pathways of arsenic in New England; arsenic and other trace elements in the Cheney Reservoir Watershed, KS; and water quality in the lower Illinois River basin in Illinois (Groschen and others, 2001; Mau, 2001; Ayotte, 2000§; Welch and others, 2000§; Alpers, 2002§; Ayuso and Foley, 2002§; Robinson and others, 2002§; Hancock and others, 2003§; Iowa Times Citizen, 2003§; U.S. Geological Survey, 2003§; Robert Seal, U.S. Geological Survey, oral commun., May 2003). Arsenic is one of several elements included in a nationwide USGS soil geochemical study (Boerngen and Shacklette, 1981). Remediation of arsenic leached from mine tailings by addition of calcite was proposed at one site in Mexico (Mendez and Armienta, 2003).

Arsenic is one of several pollutants generated by coal-fired power stations, and pollution from these stations has been blamed for some respiratory problems (Planin, 2001). Collaborative studies by the EPA and the USGS indicated that, with the possible exception of mercury, there is no evidence to indicate that emissions from U.S. coal-burning plants cause human health problems (Finkelman, 2000). U.S. coals contain an average of 22 parts per million arsenic and combustion of these coals is not considered a health risk; however, there are high arsenic coals in China that pose a health risk when the arsenic is released during combustion of coal for domestic use. The USGS, in partnership with Chinese health officials, researched health issues related to the release of arsenic and other elements as a result of domestic coal use in rural China (U.S. Geological Survey, 1998§).

Consumption

In 2003, the United States remained the world's leading consumer of arsenic with apparent demand of 21,600 t. The estimated value of arsenic compounds and metal consumed domestically during 2003 was approximately $14 million. Approximately 90% of the arsenic, as As_2O_3, was used in the wood preservative industry; the remainder was used in such agricultural chemicals as insecticides, herbicides, and fertilizers. The major U.S. producers of arsenical wood preservatives include Arch Wood Protection Inc., GA; Chemical Specialties Inc., NC; and Osmose Wood Preserving Inc., NY. The voluntary phaseout of CCA preservatives has yet to impact demand; however, phaseout now provides a marketplace for alternative products, such as lumber made from reclaimed plastic and wood waste or plastic composites (Jacobson, 2003; Irwin, 2004; Trex Company, Inc., 2003§). Other chemical applications of arsenic include use as a bubble dispersant or decoloring agent in glassmaking or for arsenic trisulfide glass, a specialty optical material (Harrick Optical Materials, 2003§).

The demand for arsenic metal is limited; however, arsenic metal may be alloyed with lead and antimony for ammunition, solders, and other applications. Arsenic is one of several metals used as an antifriction additive to metals (babbitts) used for bearings (Allen, 2000§). Grids and posts in lead-acid storage batteries are strengthened by the addition of arsenic metal. Gallium arsenide (GaAs) semiconductors are used in solar cells, light emitting diodes, and lasers (U.S. Department of Energy, 2003§). GaAs semiconductors for use in computers and electronic devices require high-purity (99.9999%-pure) arsenic metal. Arsenic is an important component of GaAs wafers for electronics applications; however, in 2002, the domestic demand for gallium and arsenic in wafer production declined significantly owing to the buildup of the domestic GaAs inventory, the closure of several domestic plants, and increased wafer manufacturing in China. Based on reported consumption of gallium, domestic consumption of arsenic metal in GaAs semiconductors fell to 19 t in 2002 from a peak of about 40 t in 2000 (Kramer, 2004). In 2003, consumption was estimated to have recovered slightly.

World Review

In 2003, As_2O_3 was obtained from the treatment of nonferrous ores or concentrates in 14 countries. Smelter dusts and residues were recovered from plants in several other countries; however, these were not processed to commercial-grade As_2O_3 and may be stockpiled for future treatment. In 2003, China remained the world's largest producer of As_2O_3, followed by Chile and Peru. Most countries do not report their As_2O_3 production, and therefore, country data are estimated.

Reduction of As_2O_3 accounts for all world output of commercial-grade (99%-pure) arsenic metal. China continues to be the world's leader in the production of commercial-grade arsenic metal, followed by Japan.

Outlook

World resources of arsenic are adequate to meet projected needs given the availability of arsenic from nonferrous metal processing in several countries.

The decision by the wood preservative industry to voluntarily eliminate the use of CCA as a wood preservative for specified wood products by the end of 2003 may lead to an oversupply of As_2O_3 until international producers adjust to the consequent decline in U.S. demand. In particular, As_2O_3 production in Chile, China, and Peru may ultimately be affected by the decline. However, there will still be a domestic market for CCA-treated wood especially for such industrial applications as marine timber, utility poles, and plywood roofing. Environmental considerations will continue to encourage the use of alternative wood preservatives, wood lumber alternatives, plastic compounds, or concrete in place of CCA-treated wood.

The electronics industry will continue to require high-purity arsenic for production of GaAs semiconductors for telecommunications, automotive uses, solar cells, and military and space applications (European Gallium Arsenide Symposium, 2002§; U.S. Department of Energy, 2003§). Arsenic metal will continue to be used in the production of ammunition and other alloys.

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TABLE 1
ARSENIC SUPPLY-DEMAND RELATIONS[1]

(Metric tons, arsenic content)

	1999	2000	2001	2002	2003
U.S. supply, imports:					
Metal	1,300	830	1,030	879	990
Compounds	22,100	23,600	23,900	18,800	20,800
Total	23,400	24,500	25,000	19,700	21,700
Distribution of U.S. supply:					
Exports[2]	1,350	41	57	100	173
Apparent demand	22,000	24,400	24,900	19,600	21,600
U.S. use:[e]					
Agricultural chemicals	850	950	1,000	750	860
Glass	600	700	750	700	660
Wood preservatives	19,500	21,800	21,900	17,300	19,200
Nonferrous alloys and electronics	850	700	1,000	650	660
Other	200	250	250	200	200
Total	22,000	24,400	24,900	19,600	21,600

[e]Estimated.
[1]Data are rounded to no more than three significant digits; may not add to totals shown.
[2]Metal only.

TABLE 2

U.S. IMPORTS FOR CONSUMPTION OF ARSENIC PRODUCTS[1]

Class and country	2002 Quantity (metric tons)	2002 Value (thousands)	2003 Quantity (metric tons)	2003 Value (thousands)
Arsenic trioxide:				
Belgium	205	$136	381	$244
Bolivia	60	34	150	86
Chile	2,160	958	181	94
China	16,800	8,330	20,600	9,910
Germany	16	59	7	28
Hong Kong	516	261	191	114
Japan	--	--	94	62
Mexico	688	495	612	444
Morocco	4,210	2,330	5,130	2,790
Total	24,700	12,600	27,300	13,800
Arsenic acid, Canada	1	4	--	--
Arsenic sulfide, Canada	--	--	1	6
Arsenic metal:				
China	733	1,710	827	1,630
Germany	3	535	3	515
Japan	144	1,140	160	896
United Kingdom	(2)	5	--	--
Total	879	3,390	990	3,040

-- Zero.

[1]Data are rounded to no more than three significant digits; may not add to totals shown.

[2]Less than 1/2 unit.

Source: U.S. Census Bureau.

TABLE 3

ARSENIC TRIOXIDE: ESTIMATED WORLD PRODUCTION, BY COUNTRY [1, 2, 3]

(Metric tons)

Country[4]	1999	2000	2001	2002	2003
Belgium	1,500	1,500	1,000	1,000	1,000
Bolivia	437 [5]	318 [5]	846 [5]	237 [r, 5]	250
Canada	250	250	250	250	250
Chile	8,000	8,000	8,000	8,000	8,000
China	16,000	16,000	16,000	16,000	16,000
France	1,000	1,000	1,000	1,000	1,000
Germany	200	200	100	100	100
Ghana[6]	7,000	3,000	--	--	--
Iran	300	400	400	400	400
Japan	40	40	40	40	40
Kazakhstan	1,500	1,500	1,500	1,500	1,500
Mexico	2,419 [5]	2,522 [5]	2,381 [5]	1,946 [r, 5]	2,000
Peru[7]	1,611 [5]	2,495 [5]	2,800 [r, 5]	2,970 [r, 5]	3,000
Portugal	50	50	50	50	50
Russia	1,500	1,500	1,500	1,500	1,500
Total	41,800	38,800	35,900 [r]	35,000	35,100

[r]Revised. -- Zero.

[1]Including calculated arsenic trioxide equivalent of output of elemental arsenic compounds other than arsenic trioxide where inclusion of such materials would not duplicate reported arsenic trioxide production.

[2]World totals and estimated data have been rounded to no more than three significant digits; may not add to totals shown.

[3]Table includes data available through April 1, 2004.

[4]Austria, Hungary, the Republic of Korea, South Africa, Spain, the United Kingdom, Serbia and Montenegro, and Zimbabwe have produced arsenic and/or arsenic compounds in previous years, but information is inadequate to make estimates of output levels, if any.

[5]Reported.

[6]Production ceased in mid-2000. Ashanti Goldfields Ltd.'s Obuasi roaster closed.

[7]Output of Empresa Minera del Centro del Perú (Centromín Perú) as reported by the Ministry of Energy and Mines [Peru].